Robotic Gamma Locator Device (GLD)

Deactivation and Decommissioning Focus Area

Prepared for
U.S. Department of Energy
Office of Environmental Management
Office of Science and Technology

April 2002

INNOVATIVE TECHNOLOGY
Summary Report

Robotic Gamma Locator Device (GLD)

OST/TMS ID 2991

Deactivation and Decommissioning Focus Area

Demonstrated at
Idaho National Engineering and Environmental Laboratory
Idaho Falls, Idaho

INNOVATIVE TECHNOLOGY
Summary Report

Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine whether a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available on the OST Web site at http://apps.apps.em.doe.gov/ost/itsrall.html.

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SECTION 1
SUMMARY

Technology Summary

The United States Department of Energy (DOE) continually seeks safer and more cost-effective technologies for use in decontaminating and decommissioning nuclear facilities. To this end, the Deactivation and Decommissioning Focus Area of DOE's Office of Science and Technology (OST) sponsors “Large-Scale Demonstration and Deployment Projects” to test new technologies. As part of these projects, developers and vendors showcase new products designed to decrease health and safety risks to personnel and the environment, increase productivity, and lower costs.

The Large-Scale Demonstration and Deployment Project (LSDDP) at the Idaho National Engineering and Environmental Laboratory (INEEL) has generated a list of statements defining specific needs or problems where improved technology could be incorporated into ongoing decontamination and decommissioning (D&D) tasks. One of the stated needs was for technologies that would reduce costs and shorten D&D schedules by providing remote radiological characterization in buildings or areas with high radiation levels. Engineers at the INEEL have identified the Russian Gamma Locator Device (GLD) as being one such technology that could provide economic and safety benefits to the INEEL D&D program. Benefits of using the GLD include:

- Cost reductions for initial surveys in highly contaminated areas
- Improved presentation of data (radiation data is tied directly to a photo of the object being surveyed)
- Accelerated D&D schedule – Initial surveys are completed much quicker
- In situ near real-time radiological measurements
- Reduced personnel radiation exposure

Baseline Technology

Historically at the INEEL, radiation control technicians (RCT) and industrial safety personnel first enter a facility in order to observe conditions within the facility for planning purposes. When performing an initial radiation survey, the RCT uses a standard Geiger-Mueller pancake probe to gather radiological information. Once this initial entry has been completed, a video technician may also be required to enter and collect video footage of the facility for future work planning purposes. Finally, a team of sampling technicians is sent into the facility to collect samples (Figure 1) for determining the accurate levels of contamination for planning decontamination and disposal work.

Figure 1. Baseline Sample Collection for Laboratory Analysis.

New Innovative Technology

Engineers at the INEEL identified the Russian GLD as a technology that could provide gamma radiation measurements remotely in highly contaminated areas using a robotic platform. The GLD transmits video images and radiation measurements using radio frequency to a remote PC which also provides communication to the robot and GLD. This technology is unique to U.S. technologies because it operates on a radio frequency autonomously, or without any tethered attachment. This enhances its ability to maneuver around cluttered rooms without becoming entangled. The use of the GLD significantly reduces the need for human entry into hazardous environments.

The GLD was designed and tested in Russia. It was used during the accident at Chernobyl to identify reactor components in the debris during clean-up activities. The GLD utilizes a collimated, cesium iodide, gamma sensor. The sensor is 10 mm x 10 mm x 40 mm. The GLD corrects for distance using a laser range finder, which measures the distance prior to each radiation measurement. The system easily attaches to the robotic platform with four bolts.

The Russian GLD was demonstrated at the INEEL at Test Area North (TAN)-616. This technology and the demonstration were made available through the auspices of the DOE-HQ International Programs and the DOE- National Energy Technology Laboratory (NETL) D&D Focus Area. A robot was provided and operated by the INEEL robotics crosscut program to mobilize the GLD to remotely characterize rooms in TAN-616.

The GLD (Figure 2) provides three-dimensional characterization of radioactivity in areas ranging from moderate to high radiation activity. The GLD scans an area and quantifies the level of radioactivity while cameras onboard the GLD simultaneously video those areas being scanned. The radioactivity levels are overlaid on the video and displayed at a remote PC monitor located outside the contaminated area. This technology is unique to competing U.S. technologies because it operates on radio frequencies completely nontethered, allowing it to maneuver around corners and obstacles and transmit over long distances. It also has a broader range of sensitivity (i.e., 60KeV to 6MeV compared with 100KeV to 2MeV) and it has a broader scanning angle (i.e., 330 degrees horizontal and 125 degrees vertical compared to 73 degrees horizontal and 55 degrees vertical). The distance from the GLD to the hot spot is measured by laser range finder and can range from 0.5 to 100 meters. Counting times for radiation measurements range from 5 to 60 seconds. Different levels of radioactivity are color coded to enable the viewer to pinpoint hot spots.

Figure 2. Russian GLD

Demonstration Summary

A demonstration was originally envisioned to use the GLD to collect video and gamma radiation levels in the Liquid Waste Treatment Facility at TAN-616. The capabilities of the GLD were demonstrated to INEEL LSDDP personnel at the Russian Research Institute of Construction Technology (NIKIMT) in February 2000. During the visit it was learned that another technology provider in Russia had designed and built a technology that could remotely identify the isotopes that were the source of the radioactivity. This technology also operated non-tethered and could possibly be used in conjunction with the GLD. The addition of the Isotopic Identification Device (IID) significantly improves GLD performance by reducing the number of entries required and unnecessary personnel exposure in radioactively contaminated areas. The IID is programmed to identify Cs-137, Co-60 and Am-241 but can be programmed to identify other isotopes as well. The IID uses computer software to analyze the signal and identify the isotopes. The IID is discussed in greater detail in a separate LSDDP Innovative Technology Summary Report – "Robotic Isotopic Identification Device (IID)," OST/TMS ID 3063.

The GLD was demonstrated in July of 2001 at TAN-616. This facility was in operation from 1954 to the mid 1980s. This facility was used to treat thousands of gallons of liquid waste that resulted from years of research and testing. TAN 616 is composed of a control room, operating pump room, a pump room (located in a basement) , and an evaporator pit room. The demonstration took place in the control room, operating pump room, and pump room. The pump room was highly contaminated with mixed fission products as a result of numerous leaks in the system over time. The building has not been accurately characterized because of the hazards associated with sending workers into this contaminated environment.

The Russian GLD was compared with the following baseline activities: the initial RCT entry, an entry to collect video footage, and a final entry to collect samples. The GLD was able to collect dose information, video footage, and radiation levels in a single unmanned entry. By using the Russian GLD at TAN-616, workers received only one tenth the radiation dose of those performing baseline sampling. The cost of using the GLD was 87% of the baseline cost in this demonstration. This cost comparison was very conservative when you consider that the GLD actually collects radiation data for multiple points for each scan. The assumption in the cost analysis is made that 1 scan is equivalent to 1 sample. However the GLD completed on average 10 point measurements per scan. The cost savings would have been ten times greater had the cost analysis compared a laboratory sample to a single point measurement.

Figure 3. TAN-616

Contacts

Technical

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Licensing
Because the GLD transmits data via radio and television frequency, it is necessary to obtain licensing for the frequency used.

Permitting
No other permitting activities were required.

Other
All published Innovative Technology Summary Reports are available on the OST Web site at http://apps.apps.em.doe.gov/ost/itsrall.html. The Technology Management System (TMS), also available through the OST Web site, provides information about OST programs, technologies, and problems. The OST/TMS ID for the GLD is 2991.

SECTION 2
TECHNOLOGY DESCRIPTION

Overall Process Definition

Demonstration Goals and Objectives

The overall purpose of this demonstration was to assess the benefits that may be derived from using the GLD to collect radiation surveys and initial video footage in a contaminated facility. The GLD was compared with the baseline technology, which involved an initial entry into the facility by RCTs to determine contamination levels in order to establish safe working limitations for D&D activities. A second entry by a video team was made to collect footage for planning purposes. A third and final entry to sample various locations in the facility to determine contamination levels was also made. The primary goal of the demonstration was to collect valid characterization data to make a legitimate comparison between the GLD technology and the baseline activities in the areas of:

- Cost
- Productivity
- Ease of use
- Limitations and benefits
- Safety
- Data quality.

System Operation

The GLD is intended for remote detection (measurement of activity) of radioactive sources in hazardous nuclear environments, particularly in high radiation fields where human exposure could pose serious health risks. The GLD consists of a gamma locator, specrometrical detector, black-and-white TV camera, laser range finder, mechanical pan/tilt unit, lead screen collimator, personal computer, and software (Figure 4). The detector for the GLD is a scintillating monocrystal cesium iodide (CsI) detector, with dimensions of 12 x 12 x 12 mm.

The GLD operation is based on registration and computer analysis of dose rate and radiation spectrum composition information from the radiation sources viewed through a collimated angle. The GLD operates using onboard 12-volt DC batteries for power. For this case the signals were transmitted via two radio frequencies, 780 MHz for data transmission and 3.4 GHz for the video images. The duration or length of operation for the GLD varies based on the size of the battery and the number of movements or positions required for each scan. If additional battery life is needed, a second battery can be added to the system. During this demonstration, the battery for the GLD lasted approximately 4 hours before needing to be recharged.

The operator of the GLD has the ability to remotely vary the scan times from 5 to 60 seconds. Additionally, the operator can select the number of scanning points ranging from 1 to 64 points evenly spaced over a selected scan area. Each scan covers as little as one square foot or as much as several square feet. Each point has a separate gamma radiation measurement. The general operation of the GLD is as follows:

- The robot platform transports the GLD into the contaminated area to locations where the user chooses to perform a scan
- Using an onboard video camera the GLD collimator is oriented to the object of interest
- Count times are established
- Number of scanning points is selected
- Scanning is initiated
- Activity is measured at each scanning point
- The background is subtracted from the measurement
- The data are stored on the personal computer for the user to evaluate.

The robot used in this demonstration had an independent 12-volt battery and a 3-6 hour run time depending on the terrain and number of movements. The robot has onboard cooling fans that were disabled to prevent radioactive contaminants from entering the internal components of the robot. Tests were made prior to using the robot for this application to ensure the electronic components would not overheat due to reduced airflow resulting from disconnecting the fans. No overheating problems occurred during this test, nor did they occur during the demonstration at TAN 616. In the climate that the GLD demonstration was conducted, there would be little chance for the internal electronics to overheat even with the cooling fans disconnected. However, in a hotter climate it may be necessary to identify an option that would allow for the cooling fans to be left on or identify another method of cooling.

Figure 4. Russian GLD Mounted on the Russian Robot

SECTION 3
PERFORMANCE

Demonstration Plan

Problem Addressed

As with other DOE facilities, the INEEL is in the process of decontaminating facilities, buildings, and areas that are radiologically contaminated. A remote characterization tool for collecting radiation data in contaminated facilities was needed. As part of the data collection process, this tool should provide accurate and reproducible survey information using a remotely deployed detector. This would allow workers to remain outside the contaminated area, thus minimizing the risk of radiation exposure. In addition, visually displaying the extent of gamma contamination is highly desirable. D&D Facility Management personnel can use information from this demonstration to plan decommissioning activities for the TAN 616 facility.

Demonstration Site Description

The INEEL site occupies 569,135 acres (approximately 890 square miles) in Southeast Idaho. The site consists of several primary facility areas situated on an expanse of otherwise undeveloped, high-desert ecosystem. Structures at the INEEL are clustered within primary facility areas, which are typically less than a few square miles in size, and separated from each other by miles of undeveloped terrain.

TAN is located at the north end of the INEEL, about 27 miles northeast of CFA. TAN was established in the 1950s by the U.S. Air Force and Atomic Energy Commission Aircraft Nuclear Propulsion Program to support research in nuclear-powered aircraft. Upon termination of this research, the area's facilities were converted to support a variety of other DOE research projects.

TAN-616 was built in 1954 as a liquid waste treatment facility. As a result of treating thousands of gallons of liquid nuclear waste, there are various levels of mixed fission products, heavy metals, and organic contaminants present in the facility.

Three rooms within TAN-616 were surveyed using the Russian GLD, -- the Operating Pump Room, the Control Room, and the Pump Room (Figure 5). All of these rooms were filled with a network of pipes and equipment, like the Pump Room, making a manual survey difficult and time consuming.

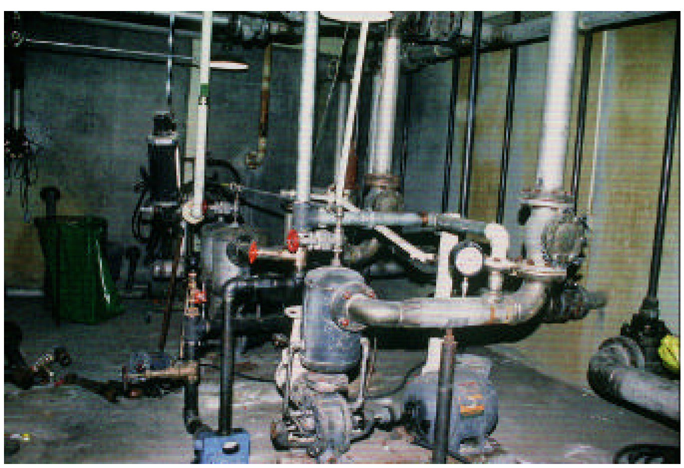

Figure 5. TAN-616 Pump Room.

Major Objectives of the Demonstration

The major objectives of this demonstration were to evaluate the Russian GLD against the baseline manual surveying and sampling in the areas of:

- Cost
- Productivity
- Ease of use
- Limitations and benefits
- Safety
- Data quality.

Major Elements of the Demonstration

The intent of this demonstration was to gather information helpful in deciding if the Russian GLD would improve D&D activities through a reduction in cost, accelerated schedule, improvement in safety, or more reliable data. The major elements for this demonstration were:

- Surveying time
- Documentation
- Number of workers required
- Safety
- Reduction in radiation dose received
- Cost
- Feedback
- Advantages/disadvantages.

The Russian GLD demonstration started in July 2001 at the TAN-616 building. This building is scheduled for D&D and was previously characterized to determine the extent of radiation contamination it contained. For the baseline technology, three rooms were selected for collecting radiation data. These rooms were the Control Room, the Operating Pump Room, and the Pump Room. The baseline characterization activities for TAN-616 started during the summer of 2000 and continued through the fall of 2000. During the demonstration, 10 scans were made in the Operating Pump Room, one in the Control Room, and nine in the Pump Room using the GLD. Each scan is composed of multiple point measurements that can range in number from 1 up to 64 points. The length of time for each scan can also be increased or decreased depending on the needs.

During the baseline characterization, radiation technicians collected contact readings at various locations in the facility and smears from 100 cm^2 areas. Workers later entered and collected samples from paint, debris, sludge, and concrete. In addition to the samples, video footage was shot in each room to provide insight for D&D planners as they prepare to decommission the facility.

Results

The demonstration of the GLD provided radiation survey results real time and was completed in 3 days. It took workers using baseline characterization methods 3 months to obtain the same data. Much of this time was spent waiting for results to be sent back from the laboratory. In addition, radiation exposure to workers supporting the GLD demonstration was cut by more than a factor of 10 over baseline activities. During baseline characterization, workers received 82 mR of radiation exposure. During the demonstration of the GLD, workers received only 7 mR of radiation exposure, which only occurred because the robot and GLD had to be manually transported down a set of stairs.

The cost of collecting the radiation measurements using the GLD was about 87% of the baseline cost. While the cost of the GLD characterization was less than the baseline cost, the real benefit is realized when the amount of data generated is also considered. There were 19 baseline samples taken during the characterization work. The GLD collected 20 scans. Even though there were only 20 scans performed at TAN-616 using the GLD, this included over 200 point measurements that covered over 100 square feet of wall and floor area. The GLD has the capability of providing 100% coverage, if needed.

The performance of the baseline and GLD technologies is compared in Table 1. During the demonstration, the GLD identified contaminated spots on walls, pipes, and equipment at TAN-616. The data was available within minutes after the GLD performed the scan. The baseline activities began in August 2000 and were not complete until November 2000. Some of the laboratory analysis results were not available until January 2001. It took a month to receive data back from the laboratory in order to confirm baseline characterization.

Less time was spent in potentially hazardous environments during the demonstration of the Russian GLD than during baseline characterization, yet more data was collected using the GLD than baseline manual characterization provides.

Table 1. Performance comparison between the GLD and the baseline surveying technology.

Performance Factor	Baseline Characterization	GLD Technology
Personnel/equipment/ time required to survey	Personnel: • 2 RCTs • 4 samplers • 1 video • 1safety • 1 field team lead Equipment: • Ludlum 2A detector • 1 field logbook • counting meter for the smears • smears • Tent • Video Camera Time: • 30 hours	Personnel: • 1 operator of GLD • 1 operator of the robot • 1 video operator • 2 RCTs Equipment: • 1 robot • 1 GLD • 1 field logbook • Tent • On-board Video Camera Time: • 18 hours
Time required to generate report	Personnel: • 1 RCT Equipment: • 1 personal computer • 1 field logbook Time: • 5 hours	Personnel: • 1 RCT Equipment: • 1 personal computer • 1 field logbook Time: • 5 hours
Total time per technology	• 35 hours	• 23 hours
Personal Protective Equipment (PPE) requirements	• Rubber gloves • Safety shoes • Clothing adequate for surveying • Respirator	• Wrap GLD
Superior capabilities	• Technology is well known and accepted for characterization surveys	• GLD was considered easier than physical sampling • This innovative technology has the ability for 100% coverage • It is much faster and more efficient in collecting data • It can provide near real-time data • The final report includes a visual display of the extent of contamination found from the survey results.

Benefits from using the innovative technology include:

- Cost reductions in initial characterization
- Ability to achieve near 100% coverage
- Significant reduction in worker as-low-as-reasonably-achievable (ALARA) dose
- Accelerated D&D schedule–shorter characterization times
- In situ near real-time radiological measurements
- Reduction in potential human error associated with manual sampling
- Less physically demanding (workers do not need to dress into respirators and full body PPE).

Operating Pump Room Results

The Operating Pump Room was the first room to be characterized during the demonstration of the GLD at TAN-616. The RCTs collected five smears (A, B, F-G) and recorded two dose measurements (C and D) at various locations in the room during the initial baseline entry (Figure 6). These baseline sample locations are identified by bold capital letters shown in Figure 6. During the sampling phase of baseline characterization, four samples (sludge, paint, and other materials) and three additional smears were collected. These seven samples were sent to a laboratory for gamma analysis. The cost was $330/sample.

During the GLD demonstration, 11 scans were made. The location of these scans is shown in Figure 6 by the bold numbers (1-11). Each scan was composed of several point measurements ranging from 9 to 25 points. Figure 7 shows a 9-point scan taken in the Operating Pump Room. A total of 120 point measurements were made using the GLD in the Operating Pump Room. A single scan may cover several square feet on a wall or network of pipe, or may be a very detailed scan of a smaller area such as 1 square foot. In Figure 7, some of the points were on the walls, some on control valves, and one on the floor. In order to collect similar data using baseline measurements, nine separate samples or smears would have been collected, whereas using the GLD, a single scan was completed in 15 seconds. The GLD uses a laser to measure distance to each surface being scanned. Therefore, each measurement has been corrected for distance from the detector.

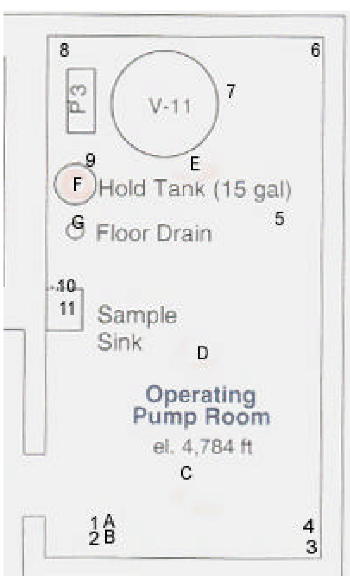

Figure 6. Characterization Map of the Operating Pump Room

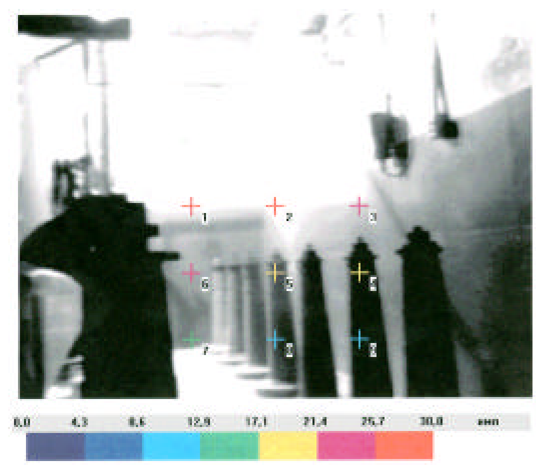

Figure 7. Radiation Scan using Russian GLD.
Note: Each cross hair represents a separate point measurement. The color of the cross hair indicates the radiation level that correlates to the scale below the graph. The units are in total counts in a given 10-second scan time. The commas can be replaced with decimal points. Multiplying the values above will give you counts per minute.

During these scans, each of the measurements taken during baseline characterization was validated using the GLD. In addition, elevated radiation readings, not reported during the baseline characterization, were found on the north wall in three locations. Elevated radiation readings were also found between the hold tank and sink on the west wall and on a pipe above the sink.

Measurements taken with the GLD and those from baseline sampling were not directly comparable. Baseline methods provide both gamma radiation measurements and isotopic information while the GLD provides only gamma measurements. All activities included in the baseline are required and used routinely to characterize rooms or facilities for entry and work planning. Although it may appear that the cost benefit for the baseline should be adjusted because of isotopic information, it in fact represents the actual cost of performing the same work had the GLD not been in existence, hence baseline cost. The baseline includes smears, samples of paint, solids, and liquids for laboratory analysis, and contact and gross area gamma radiation measurements with a geiger-mueller pancake probe. Measurements from the GLD were timed scans of an area to collect several point measurements that identify gamma radiation levels only. Although the data was not directly comparable the resulting conclusions were the same. Areas with elevated radiation levels were identified and confirmed by both methods. The major difference was the GLD covered more area with more precision than did the baseline, and was able to identify areas of elevated levels not detected using the baseline methods. For isotopic information another instrument was added to the GLD and robot. The report on the Isotopic Identification Device (IID) can be viewed in the "Isotopic Identification Device (IID), Innovative Technology Summary Report", TMS # 3063.

Control Room Results

During the initial entry, RCTs collected two smears in the Control Room. The results of the smears were readings less than 0.5 mR/smear. Two paint samples were sent to the laboratory for analysis, but neither had detectable radiation. One scan was performed in the Control Room using the GLD. Figure 8 shows the location of the baseline samples represented by bold letters (A-B) and the location of the GLD scan by the bold number 1.

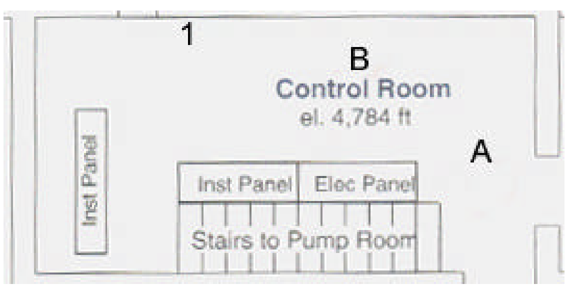

Figure 8. Characterization Map of the Control Room.

The GLD scanned a pipe on the north wall of the Control Room and found significant levels (greater than 4,000 counts per minute above background) of gamma radiation. This scan was composed of 15 point measurements. No other measurements were made in the Control Room. Figure 9 shows the one scan made in the Control Room using the GLD.

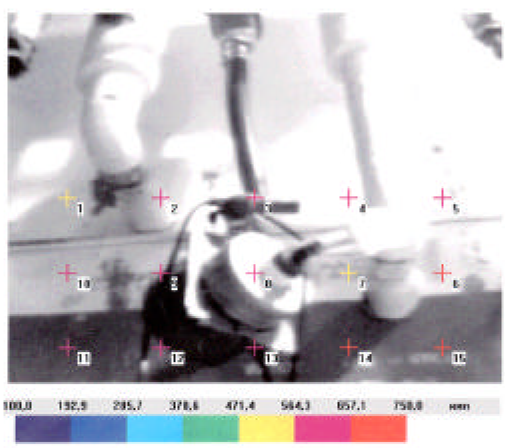

Figure 9. Radiation scan using Russian GLD in TAN-616 Control Room.

Note: Each cross hair represents a separate scanning point. The color of the cross hair indicates the radiation level that correlates to the scale below the graph. The units are in total counts in a given 10-second scan time. The commas can be replace with decimal points. Multiplying the values above will give you counts per minute.

Pump Room Results

RCTs collected seven smears (A-B, D-H) during the initial entry in the Pump Room and reported one direct measurement (C) (see Figure 10). Radiation levels in the pump room were much higher than those observed in the previous two rooms. Sample technicians also collected eight smears and collected a sludge sample and a sample of rubber hose. These samples were sent to a laboratory for analysis. Results of the smears ranged from 2,090 pCi/smear to 72,700 pCi/smear. Sample locations for baseline measurements are shown in Figure 10 as represented by the bold letters.

The GLD performed eight scans (1-8) in the area. These eight scan locations are shown in Figure 10 as denoted by the bold numbers. The number of point measurements per scan ranged from 1 to 20 points, with a total of 91 point measurements taken in the entire room. In this room, the GLD and robot began to lose communication when they began passing the first pump (P-1) heading in the north or upward direction on the map, which was approximately half of the way across the room. The loss of communication with the robot and GLD resulted from a combination of the distance from the transmitter and the congestion of equipment in the pump room. This congestion can block or interrupt the pathway for the radio waves from the transmitter located at the control station and the receiver on the GLD. The communication pathway from the transmitter to the GLD started outside of TAN 616, entered the building, continued around a corner, down a stairwell and around another corner into the pump room. Because of the difficulty in maintaining communication over this distance, we were unable to validate two of the smears taken by the RCT on the north side of the room. In order to maintain or regain communication with the robot, the transmitter for the robot was moved farther into the facility. This made it possible for the operators to regain communication with the robot. The robot moved back to its original position in the pump room and allowed the GLD to regain communication from its transmitter. Figure 11 shows the point measurements of the sump located in the bottom right corner of the room shown in Figure 10.

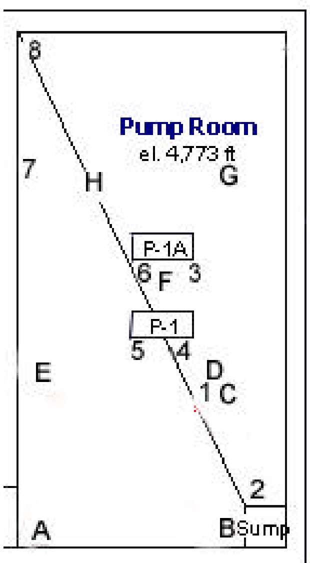

Figure 10. Characterization Map of the Pump Room.

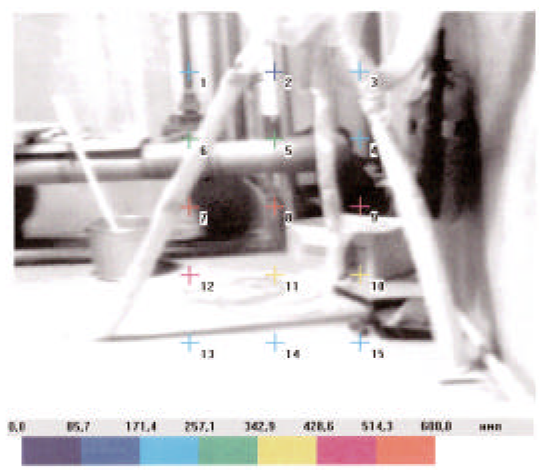

Figure 11. Radiation scan using Russian GLD in TAN-616 Control Room

Note: Each cross hair represents a separate scanning point. The color of the cross hair indicates the radiation level that correlates to the scale below the graph. The units are in total counts in a given 10-second scan time. The commas can be replace with decimal points. Multiplying the values above will give you counts per minute.

SECTION 4
TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Competing Technologies

Baseline Technology

The baseline technology, characterization of radionuclide contaminated facilities, consists of first an entry by RCTs to assess the levels of contamination and whether the contamination is airborne, fixed, or loose. Once this has been accomplished, a radiation engineer determines what level of protection is needed for workers to enter the area including stay times based on dose measurements. Then technicians enter a second time to collect physical samples for laboratory analysis. A third entry was made for the purpose of collecting video footage of the contaminated facility for planning purposes. Workers can then view the footage to identify potential hazards prior to entering the facility.

Other Competing Technologies

A broad range of radiation survey equipment is available such as plastic scintillation, NaI detectors, and germanium detectors. Most of these technologies require a user to carry the detector into the contaminated facility. There are also remotely deployed detectors that require a tether for communication and control. The GLD is unique in its ability to transmit data and video back to the operator without using a tether. The GLD also has a greater viewing angle and a broader sensitivity than baseline technologies.

Technology Applicability

The GLD is fully developed, but it has not been made commercially available. Its superior performance over the baseline technology makes it a prime candidate for deployment at many contaminated sites. The system can easily be combined with a variety of robotic platforms. Commercially available batteries can be purchased that are capable of effectively powering the GLD and robotic platform.

Patents/Commercialization/Sponsor

The GLD is available from:

The Research and Development Institute of Construction Technology (NIKIMT)
Nikolai Sidorkin
Altufyevskoye Shossee 43
Moscow, Russia 127410
(7-095) 489-9095

Currently the INEEL is acquiring a GLD for commercialization through an ASTD project and NIKIMT and a U.S. company are pursuing commercialization activities.

SECTION 5
COST

Introduction

This section compares the cost of the innovative and the baseline technologies for first response following a release or in highly contaminated areas. Basis of all costs is the demonstration survey of a control room, an operating pump room, and a pump room containing scattered objects and equipment. The innovative technology cost is approximately 87 percent of the baseline technology's cost for a first response survey. However, in terms of unit cost per sample (baseline) and the unit cost per scan (innovative technology) the cost difference is more significant. Nineteen samples were tested using baseline technology and 20 scans were performed with the innovative technology. This comparison was very conservative when you consider that the GLD actually collects radiation data for multiple points for each scan. The assumption is made that 1 scan is equivalent to 1 sample. However the GLD completed on average 10 point measurements per scan. The cost savings would have been ten times greater had the cost analysis compared a sample to a single point measurement.

Methodology

This analysis for first response or highly contaminated areas is based on Government ownership of the innovative technology equipment and the baseline equipment. Baseline technology is primarily hand tools and hand held equipment. The innovative system includes the GLD equipment mounted on a robotic platform. Government ownership of the equipment is used in this analysis because it provides the most accurate cost comparison for the baseline technology to the innovative technology. Hourly equipment usage rates were computed for the innovative technology and the necessary robotic transporting equipment. Each rate includes ownership costs and operating costs for an equipment service life of 5,000 hours.

In this demonstration, Russian personnel provided GLD operation assistance for the innovative technology.

This cost analysis assumes that both the innovative technology and the baseline technology use site labor. The crews used in the cost analysis are based on the test engineer's judgment. Crews include a hygienist at one quarter time and a supervisor present one-day because they are not required to be present for the duration of survey work. The assumption is that both would perform duties at multiple jobs. The cost analysis is based on current burdened labor rates for the labor categories conducting this work.

In some cases, the activity duration observed during the demonstration does not represent the cost of typical work because of the artificial affects imposed on the work. These artificial affects are the result of the need to collect data, first time use of the equipment, and other effects associated with the demonstration. In these cases, the observed duration is adjusted before using them in the cost analysis. An example is the presence of additional management, INEEL staff, and others present as observers during the demonstration of the Russian equipment. These types of manpower and events were not included in the cost analysis. No other potential discrepancies between the demonstration and typical work were observed.

Additional details of the basis of the cost analysis for the surveys are described in Appendix C.

Cost Analysis

Costs to Procure Innovative Equipment

The innovative technology would be acquired by a direct purchase. The cost associated with this acquisition is indicated in Table 2.

Table 2. Innovative Technology Costs

Acquisition Option	Item Description	Cost

Purchase	Gamma Locating Device (GLD)	$50,000
Purchase	Robotic Platform	$20,000

Unit Costs and Fixed Costs

Table 3 shows the unit costs and fixed costs for both innovative and baseline technologies. The fixed costs are the sum of the line items shown in Table C-2 and C-3 of Appendix C that do not vary directly with the size of the job. They include ALARA review, project management, travel and transportation of the equipment to and from the job-site, and storage. The unit costs are the sum of the line items shown in Table C-2 and C-3 of Appendix C that do vary with the size of the job. The sum of unit costs is divided by the number of samples (19 ea. - baseline) or the number of scans (20 ea. - innovative technology) to arrive at a unit cost per sample/scan.

Table 3. Summary of Unit Costs and Fixed Costs

COST ELEMENT	INNOVATIVE COST	BASELINE COST
Fixed Costs	$ 1,966	$ 1,875
Variable Costs	$ 20,107	$ 23,397
Number of Units	20 ea.	19 ea.
Unit Costs	$1,005 per scan	$1,231 per sample
TOTAL COSTS	$ 22,073	$ 25,272

Note: The fixed costs are the sum total of individual tasks that are fixed and do not change based on the number of scans or samples; and these line items are indicated in the right hand column of Table C-2 and Table C-3. The unit costs are the sum total of all costs that vary with the quantity of work and the sum total is divided by the number of scans for the innovative technology and by the number of samples for the baseline technology. Those line items that make up the unit cost are indicated in the right hand column of Table C-2 and Table C-3.

Break-Even Point

This analysis assumes the innovative technology is purchased and owned by the Government. Cost of equipment is recouped by an hourly equipment rate. The baseline technology also utilizes Government owned equipment. Variable unit cost savings of the innovative technology over the baseline technology is approximately $226 per sample ($1,231 minus $1,005, assuming equivalent survey results for 1 sample and 1 scan). At this savings, approximately 309 scans (Figure 12) would make up for the purchase price of the innovative technology equipment ($70,000 / $226 per sample = 309 scans).

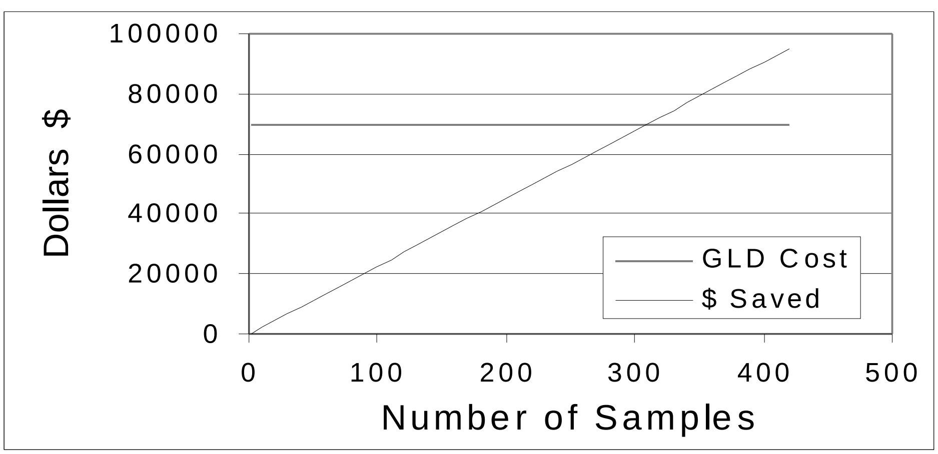

Figure 12. Breakeven Analysis

Safety and Exposure Concerns

Radiological exposure during the demonstration was 82 mR for the baseline technology and only 7 mR during the demonstration of the GLD. Using the innovative technology resulted in a reduction in radiation exposure of 75 mR. While the values themselves are not significant, the fact the use of the GLD resulted in a factor of more than 10 times reduction in radiation dose received is significant. While it is difficult to affix a dollar value to reduction in dose received, the DOE has established monetary savings resulting from dose reduction of $6,800 per man Rem. On jobs where the radiation exposure is much higher, a reduction in exposure of 10 times would be significant.

Observed Costs for Demonstration

Figure 13 summarizes the costs for the innovative and baseline technology based on 20 scans and 19 samples respectively. Figure 13 is the comparison of overall scan and sample unit costs. The details of these costs are shown in Appendix C and includes Tables C-2 and C-3 which can be used to compute site-specific cost by adjusting for number of samples or scans, different labor rates, crew makeup, etc.

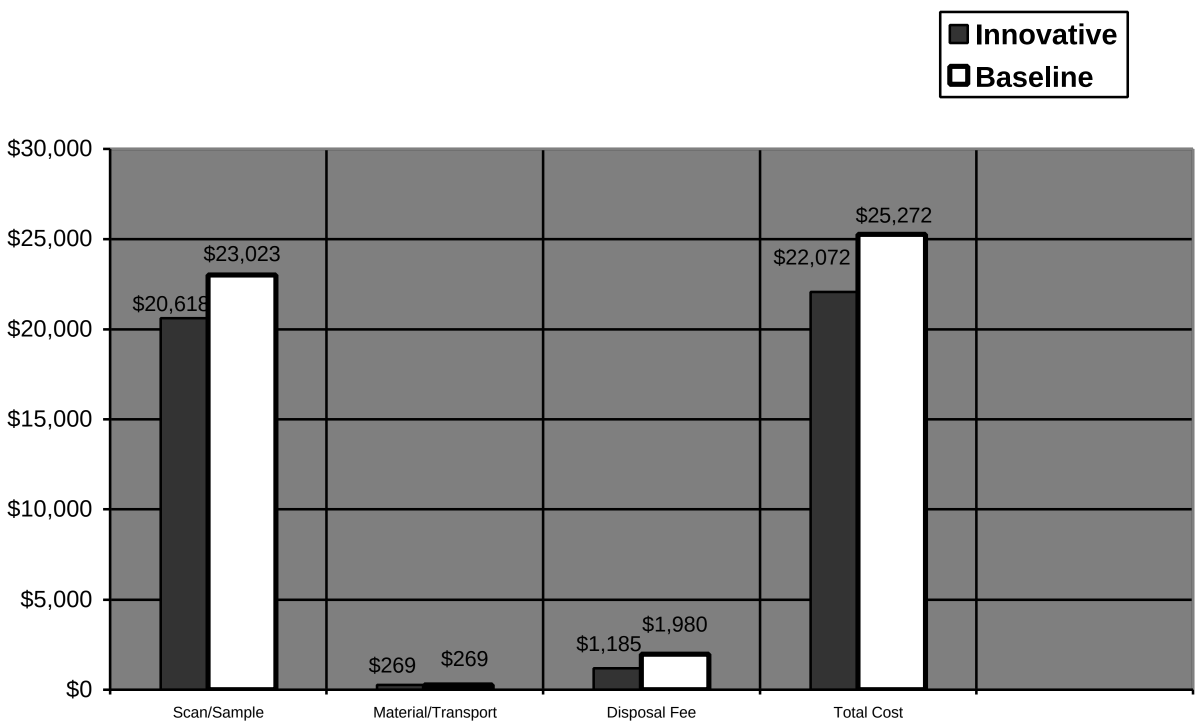

Figure 13. Summary of Technology Unit Costs Totals by Work Breakdown Structure

Cost Conclusions

The innovative technology costs for **Investigation and Monitoring/Sample Collection** (work breakdown structure # 4.07.14) is primarily variable costs associated with time, labor, and equipment to conduct a room survey for first response. The cost is also dependent upon the specifics of each individual project. Examples of individual variables may include requirements for specific isotope detection, the field of view desired, the level of detection, and the geometry of each scan.

Unit costs are based on completing 20 scans with the innovative technology 19 samples with the baseline technology. As the room size increases, the economies of the innovative technology would be significant. This is illustrated by the demonstration. Overall demonstration time for both baseline and innovative were approximately equal, 36 and 39 hours respectively. The comparison of the innovative technology to the baseline technology appears to be sensitive to the job size. Although the hours were similar, the job was completed in 3 days using the GLD and took between 3 and 4 months to complete using the baseline process. This is because the GLD provides data within minutes of the scan.

The innovative technology and baseline technology costs for **Materials Handling/Transportation** (Environmental Cost Element Structure work breakdown structure #4.13) and **Disposal Facility** (Environmental Cost Element Structure work breakdown structure #4.32) may vary in cost from one DOE site to the next. But, the variation in these costs is not anticipated to affect the cost comparison between the innovative technology and the baseline technology. The difference in disposal cost between the baseline and innovative technology are a result of less PPE (tyvek suits, respirators, glove, boots, etc) are required when using the innovative technology and no smears need to be disposed of with the innovative technology. The cost of equipment covering is approximately the same for the baseline and innovative technology.

The innovative technology cost savings over the baseline technology will vary depending on the site-specific requirements of the work. Assuming the necessary data from 1 sample test equals 1 scan result, then for most real work situations, the innovative technology should cost approximately 87 percent of the baseline cost for general area surveys. This comparison was very conservative when you consider that the GLD actually collects radiation data for multiple points for each scan. The assumption is made that 1 scan is equivalent to 1 sample. However the GLD completed on average 10 point measurements per scan. The cost savings would have been ten times greater had the cost analysis compared a sample to a single point measurement.

SECTION 6
OCCUPATIONAL SAFETY AND HEALTH

Prior to arrival at the INEEL, the Research and Development Institute of Construction Technology (NIKIMT) identified all hazards associated with the instrumentation and operation of the GLD. The primary hazard associated with this technology is the weight of the remote head while lifting and mounting it on the robotic platform. The weight of the head is in excess of 60 pounds and requires two people to safely lift and install it on the robot.

During operation of the GLD, it was recommended by NIKIMT personnel to avoid lingering in front of the antennas, as potential exposure to the transmitter signal should be avoided when ever possible.

All NIKIMT personnel were required to attend a training course on the general health and safety procedures specific to the INEEL. Included in this training was the facility access and general employee radiological training. This training was required to raise the awareness of hazards associated with radiological and industrial work specific to the demonstration and deployment of the GLD at the INEEL's facilities.

Pre-job and post-job briefings were conducted on a daily basis during the execution of this demonstration. Hazards associated with this demonstration area were explained during the pre-briefings, and the appropriate PPE was also discussed. During the pre-job briefings, the Job Safety Analysis documentation was reviewed and all hazards and potential hazards were reviewed, and mitigated where possible. The post-job briefings reviewed any problems or potential hazards, observations, and recommendations for future deployments.

Safety Advantages of the GLD

The purpose of the demonstration of the GLD was to show significant improvements in data acquisition and cost savings, and to increase worker safety. The most significant benefit of the GLD is the quality of the results relative to the safety of the workers. Because the GLD is operated remotely, fewer workers are required to enter the contaminated area.

During the demonstration of the GLD, there were more workers overall who participated in the demonstration than participated in the baseline characterization. However, during the baseline sampling activities, six entries with as many as six individuals per entry were made, totaling 60 work hours spent in the contaminated area. During the GLD demonstration, only two technicians and one RCT were required to enter the contaminated facility for a total of 10 work-hours spent in a contaminated area. All others associated with the project were able to complete the objectives from outside the contaminated areas. As a result of workers spending less time in the radiation areas, they received 10 times less radiation dose than workers during baseline activities.

In addition, the two technicians and one RCT who did enter the facility during the demonstration did so only to assist the movement of the GLD up and down a flight of stairs and to check air quality prior to entering the facility. These individuals maintained as much distance between themselves and the highest contaminated areas as possible. In contrast, the baseline samplers were required to come in direct contact with the contaminated material in order to collect representative samples.

SECTION 7
REGULATORY AND POLICY ISSUES

Regulatory Considerations

Currently, the GLD operates at a radio frequency that is not commercially acceptable in the U.S. The demonstration of the GLD was accomplished under a test variance to the Federal Communication Commission (FCC) regulation. The radio frequency used for future deployments can be easily changed. It does meet the requirements specified in DOE-STD-1098-99, "Radiological Control," dated July 1999. For this demonstration, a test plan and the technical procedure covered the use of the GLD under the INEEL LSDDP.

Safety, Risks, Benefits, and Community Reaction

The safety issues associated with the use of the GLD are primarily setting up the equipment to perform the scan. During this demonstration, the GLD and robot had to be moved down a flight of stairs. This required that some preplanning be performed in order to prevent back strains or other injuries. The benefits of the remote operation of the GLD far outweigh the potential hazards. The ability to collect radiological data without having to send in workers is a tremendous safety benefit. There was a concern identified by an industrial safety worker during the demonstration. The worker felt that a sign should be affixed to the antenna at the workstation that warned workers not to stand next to the transmission antenna for extended periods of time.

The GLD has the ability to provide 100% coverage for gamma radiation detection. It would be completely uneconomical to attempt 100% coverage using baseline data collection techniques.

SECTION 8
LESSONS LEARNED

Implementation Considerations

The GLD is fully developed and has been used in many characterization jobs in Russia. It is capable of collecting near real-time survey data remotely in contaminated areas. Operating the GLD and robot required user training and familiarity. Based on the demonstration, this technology is much faster and easier to use than the baseline hand-survey methodology. The system generated higher-quality documentation of the survey, with visual presentation of contamination results. Items that should be considered before implementing the GLD include the following:

- The user must verify that the radio frequency used is compatible with FCC regulations for that area.
- It would be very beneficial for NIKIMT to utilize software available in the U.S. for data presentation and collection. GLD measurements could not be saved electronically using standard software available in the U.S. Hard copies were printed of the scans performed during the demonstration, but this resulted in a lot of data points that had to be reentered into the computer for computations.
- During the demonstration, an INEEL robot was used to mobilize the GLD. Two INEEL operators and two Russian operators were required for the demonstration. It is expected that if the GLD is made commercially available in the U.S. a single operator could operate both the GLD and robot. The individual may need one assistant to help adjust camera views.
- If this technology is demonstrated or deployed again in the U.S., it should be noted that it required several months for the GLD to clear customs for both Russia and the U.S.

Technology Limitations and Needs for Future Development

The GLD was fully developed for use in Russia. Most of the limitations are results of differences in U.S. requirements versus Russian requirements.

- As mentioned above, the user must ensure that the radio frequency used is compatible with local FCC regulations.
- Using software that is commonly used in the U.S. and other countries such as Excel or Quattro Pro to generate the data reports would be very beneficial.
- The user communicates with the GLD using radio frequency. The radio waves are reflective, so an open path is required for communication. If communication is required over long distances or through a network of corridors or rooms, intermittent relay antennas can be used to achieve communication without requiring human entry.
- The cooling fan in the robot was disconnected to prevent spread of contamination. Another method for cooling the electronics should be considered when the technology is used in a radiologically contaminated environment.

APPENDIX A
REFERENCES

Conner, Craig, 2001, "Isotopic Identification Device (IID)", *Innovative Technology Summary Report*. Department of Energy, OST/TMS ID 3063.

APPENDIX B

INEEL ROBOTIC PLATFORM

Figure B-1 is the robotic platform that was used for demonstrating the Russian GLD. Technical specifications of this robotic platform are given in Table B-1.

Figure B-1. INEEL robotic platform

Table B-1. Technical specifications of the GLD robotic platform.

Sonar	17 (6 forward, 10 side and 2 rear facing)
CPU	Pentium II processor
Communications	Wireless 3Mbps Ethernet
Networking	Onboard 10baseT
Batteries	2 lead acid, 672 W/hr
Run Time	3 to 6 hours terrain dependent
Motor	2 high-torque, 24-V DC servo motors
Drive	4-wheel differential
I/O Ports	Joystick, RS-232, FARnet
Turn Radius	Zero (skid steer)
Translate Speed	1 m/s (3.3 ft/s)
Rotate Speed	120 degrees per second
Payload	25 kg (55.1 lbs)
Dimensions	**Height –** 55 cm (21.6 in.) **Length –** 77.5 cm (30.5 in.) **Width** – 64 cm (25.2 in.)
Weight	50 kg (110 lb.)

APPENDIX C

COST COMPARISON DETAILS

Basis of Estimated Cost

The activity titles shown in this cost analysis come from observation of the work. In the estimate, the activities are grouped under higher-level work titles per the work breakdown structure (WBS) shown in the ***Environmental Cost Element Structure*** (ECES).

The costs shown in this analysis are computed from observed duration and hourly rates for the crew and equipment. The following assumptions were used in computing the hourly rates:

- This cost analysis assumes the Government owns the innovative technology equipment.
- The equipment hourly rates for equipment that is owned by the Government is based on general guidance contained in Office of Management and Budget (OMB) Circular No. A-94, ***Cost Effectiveness Analysis***. This involves amortizing the purchase price of the equipment over the anticipated service life of the equipment. The rates also include annual maintenance costs. A service life of five thousand hours is assumed for the innovative technology and robotic equipment.
- Some of the equipment used in the course of the demonstration is commonly included in the site motor pool, such as vehicles. The equipment rates for these types of equipment are based on standard fleet rates for INEEL.
- Labor rates used in this estimate are burdened rates including salary, fringes, overheads, and other facility markups.
- The basic crew used for the baseline cost analysis is based on the test engineer's judgment including two radiological control technicians, two radiological engineers, one industrial hygienist, two sample technicians, and one job supervisor.
- The basic crew during GLD scanning included a hygienist at one-quarter time, two radiation control technicians, two test engineers, one robotics engineer, and one robotics technician.

The analysis does not include costs for oversight engineering, quality assurance, administrative costs for the demonstration, or work plan preparation costs.

Activity Descriptions

The scope, computation of production rates, and assumptions (if any) for each work activity is described in this section.

INVESTIGATIONS AND MONITORING/SAMPLE COLLECTION, CONTAMINATED BUILDING/STRUCTURES SAMPLES (WBS 4.07.14)

ALARA REVIEW: This activity includes the time required for the Radiation Engineer/s to complete a review of the current conditions at the site and make a determination for stay times and acceptable dose levels to be received by the workers.

PICKUP & CHECK (CALIBRATE) EQUIPMENT: This activity includes picking up the GLD and robot from a storage facility in the case of the innovative technology and transport of the baseline technology equipment from a storage facility to the work area. Time required for this activity for both the baseline and innovative technology is based on the judgment of the test engineer.

PROJECT MANAGER: This line item accounts for the time a project manager will input into the project in planning and preparing to complete the task.

INITIAL SURVEYS: The following activities are required to complete the initial surveys which are made by radiation control technicians prior to the startup of the task.

TRAVEL TO WORK AREA: This activity is the crews travel time to the work area based on the duration observed in the demonstration.

PRE-JOB BRIEFING: The duration of the pre-job safety meeting is based upon the observed time during this demonstration. Activities included the worksite check-in and a review of the safety plan. The labor costs for this activity are based upon an assumed crew (rather than the actual demonstration participants, and all subsequent activities are based on the assumed crew).

DON PPE AND ENTER: This activity includes the labor and material cost for donning the articles of clothing listed in Table B-1 and entry of the radiological control zone. The estimates assume that the workers leave the radiological control zone for lunch breaks and this requires an additional doffing and donning of PPE.

DOFF PPE: This activity applies to both the innovative technology and the baseline technology and includes the labor costs for doffing PPE and is based on the duration observed in the demonstration.

TRAVEL BACK: This activity is the crews travel time from the work area based on the duration observed during the demonstration.

SAMPLING ACTIVITY: This section applies to both the baseline and innovative activity. However, some items only relate to the baseline while others relate only to the innovative technology, for example bagging the GLD obviously only applies during the innovative activities.

TRAVEL TO WORK AREA: This activity is the crews travel time to the work area based on the duration observed in the demonstration.

PRE-JOB BRIEFING: The duration for the pre-job safety meeting is based upon the observed time for the demonstration. Activities included the worksite check-in and a review of the safety plan. The labor costs for this activity are based upon an assumed crew (rather than the actual demonstration participants, and all subsequent activities are based on the assumed crew).

UNLOAD AND SETUP: The time required for daily checks and calibration is based on duration observed in the demonstration.

DON PPE AND ENTER: This activity includes the labor and material cost for donning the articles of clothing listed in Table B-1 and entry of the radiological control zone. The estimates assume that the workers leave the radiological control zone for lunch breaks and this requires an additional doffing and donning of PPE.

Table C-1 Cost for PPE (per man/day)

Equipment	Cost Each	Number of Times Used Before Discarded	Cost Each Time Used ($)	No. Per Use	Cost Per Use ($)
Boot Covers (pair)	$1.02	1	$1.02	2	$2.04
Rubber boots with liner pair	$64.98	50	$1.30	2	$2.60
Facepiece	$18.98	30	$0.63	1	$0.63
Filter Cartridge	$7.43	1	$7.43	1	$7.43
Cleaning Wipes/ Consumables	$2.00	1	$2.00	1	$2.00
Glove liners pr. (cotton inner)	$0.40	1	$0.40	2	$0.80
Rubber Gloves pair (outer)	$1.51	1	$1.51	2	$3.02
Coveralls (white Tyvek)	$4.66	1	$4.66	2	$9.32
Hood	$0.85	1	$0.85	2	$1.70
Hard Hat	$11.45	30	$0.38	1	$0.38
Face Shield	$27.74	20	$1.39	1	$1.39
Safety Glasses	$4.80	30	$0.16	1	$0.16
TOTAL COST/USE/PERSON					**$31.47**

SAMPLING: This activity applies only to the baseline. Sampling is the physical removal of a sample for analysis and testing. The sampling time reported in this section is based on the actual sample time observed in the demonstration.

BAG GLD: This activity applies only to the innovative technology. Work is preparatory to entering contaminated space.

ASSEMBLE ROBOT AND GLD SYSTEM: This activity applies only to the innovative technology. Tasks include placing the GLD on the robot and testing the robotic system. The time required for this activity is based on observations during the demonstration.

SCANNING: This activity applies only to the innovative technology. Scanning is performed remotely by a robotics technician with over-site by a robotics engineer. Data interpretation is performed by the test engineers. Time required for the tasks under this activity is based on the duration observed during the demonstration.

EXIT AND UN-BAG EQUIPMENT: This activity applies only to the innovative technology. Tasks include removal of protective covering and disassembling GLD and robot equipment. This effort is assumed to reduce or eliminate decontamination of the equipment. The time required for this activity is based on observations during the demonstration.

DOFF PPE: This activity applies to both the innovative technology and the baseline technology and includes the labor costs for doffing PPE and is based on the duration observed in the demonstration.

TRAVEL BACK: This activity is the crews travel time from the work area based on the duration observed during the demonstration.

VIDEO COLLECTION:

TRAVEL TO WORK AREA: This activity is the crews travel time to the work area based on the duration observed in the demonstration.

PRE-JOB BRIEFING: The duration for the pre-job safety meeting is based upon the observed time for the demonstration. Activities included the worksite check-in and a review of the safety plan. The labor costs for this activity are based upon an assumed crew (rather than the actual demonstration participants, and all subsequent activities are based on the assumed crew).

UNLOAD AND SETUP: The time required for daily checks and calibration is based on duration observed in the demonstration.

DON PPE AND ENTER: This activity includes the labor and material cost for donning the articles of clothing listed in Table B-1 and entry of the radiological control zone. The estimates assume that the workers leave the radiological control zone for lunch breaks and this requires an additional doffing and donning of PPE.

VIDEO: This activity applies only to the baseline. Sampling is the physical removal of a sample for analysis and testing. The time allotted to video collection for this activity is based on the duration observed in the demonstration.

EXIT AND UN-BAG EQUIPMENT: This activity applies only to the innovative technology. Tasks include removal of protective covering and disassembling GLD and robot equipment. This effort is assumed to reduce or eliminate decontamination of the equipment. The time required for this activity is based on observations during the demonstration.

DOFF PPE: This activity applies to both the innovative technology and the baseline technology and includes the labor costs for doffing PPE and is based on the duration observed in the demonstration.

TRAVEL BACK: This activity is the crews travel time from the work area based on the duration observed during the demonstration.

OTHER ACTIVITIES: This activity is used to describe the time during the demonstration of the innovative technology where data was being interpreted, adjustments were being made, calibrations were being checked etc. All of the personnel remained onsite, but were waiting for sampling activities to resume.

RETURN EQUIPMENT TO STORAGE: This activity applies to both the innovative technology and the baseline technology and includes transporting the equipment back to the respective storage facilities and unloading. The activity duration is based on the duration observed in the demonstration and the test engineer's judgment.

FINAL POST JOB BRIEFING: Following the completion of the task, post job briefing is held to review the outcome of the sampling activity, discuss the results, and evaluate the success of the project.

DISPOSAL FACILITY, DISPOSAL FEES AND TAXES (WBS 4.13)

DISPOSAL: The laboratory analysis fee includes the cost of returning the sample remains and that effort is not shown as a separate cost in this analysis. This cost is for disposal of PPE used in the course of the work and is based on the assumption that each worker generates 0.66 cf of waste per day. The baseline technology requires a number of individuals to don PPE for each sampling activity. This will include RCT’s and sampling technicians. For the innovative technology it is estimated that two workers will don PPE for each scanning activity. Disposal costs at INEEL are assumed to be $150 per cubic foot of waste based on historic costs observed at INEEL for operation of the disposal cell. These costs do not include costs for transportation, packaging the waste, closure of the disposal facility, or long term maintenance and surveillance.

MATERIALS HANDLING/TRANSPORTATION (WBS 4.32)

SOLID WASTE TRANSPORT: This activity applies to both the innovative technology and the baseline technology and includes loading the waste onto a truck, transport to the disposal area, and unloading. The activity estimate is 1 hour to load, 1 hour to transport, and 1 hour to unload for each trip based on previous experience at INEEL.

Cost Estimate Details

The cost analysis details are summarized in Tables C-2 and C-3. The tables break out each member of the crew, each labor rate, each piece of equipment used, each equipment rate, each activity duration and all production rates so that site specific differences in these items can be identified and a site specific cost estimate may be developed.

Table C-2. Baseline Technology Cost Summary

Unit/ Fixed Cost	Work Breakdown Structure	Unit	Unit Cost $/Unit	Quantity	Total Cost	Computation of Unit Cost							Comments
						Prod Rate (unit/hr)	Duration (hr)	Labor Item	$/ Activity	Equipment Items	$/hr	$/ Activity	
	Facility Deactivation, Decommissioning, & Dismantlement											**Total Cost =**	**$ 25,272**
	INVESTIGATIONS AND MONITORING/SAMPLE COLLECTION, CONTAMINATED BUILDING/STRUCTURES SAMPLES (WBS 4.07.14)											Subtotal =	$ 23,023
Fixed	ALARA Review	Hr	86.48	4	346								
Fixed	Init. Pickup/Check Equip.	Hr	183.31	1	183		1	RCT,2ST	162.12	PU,ST	21.19		
Fixed	Project Manager	Hr	100.00	8	800								
Unit	Initial Surveys											Initial Survey	
						73.65	10	TL	736	PU	9.02	90	
						66.48	10	IH	664	ST	1.57	16	
						52.12	10	2-RCT	1042	PPE	12.60	126	
						52.12	10	2-TE	1042				
		Hr	371.80	10	**3,718**				**3,486**			**232**	
Unit	Sampling							**1st Sampling Activity**					
						66.48	16.25	IH	1080	2-PU	18.04	293	
						52.12	16.25	2-RCT	1693	2-ST	3.14	51	
						86.48	16.25	2-RE	2810	PPE	11.57	188	
						55.00	16.25	2-ST	1787				
		Hr	790.45	10	**7,905**				**7372**			**532**	
Unit	Video Collection							**2nd Sampling Activity**					
						52.12	6	2-RCT	625	2-ST	6.28	37	
						86.48	6	2-RE	1037	PPE	21.00	126	
						55.00	6	4-ST	1320	PU	18.05	108	
		Hr	542.50	6	**3,255**				**2,983**			**272**	
Unit	Sample Test	Ea	330.00	19	**6,270**								
Fixed	Return Equip. to Storage	Hr	183.31	.5	92		.5	RCT,2ST	162.12	PU,ST	21.19		
Fixed	Final Post Job Briefing	Hr	453.68	1	454		1	IH,2RCT,2RE,2ST	453.68				
	MATERIALS HANDLING/TRANSPORTATION (WBS 4.32)											Subtotal =	$ 269
Unit	Solid Waste Transport	hr	89.65	3	$ 269		3	TD, LB, 1/4 EO	57.96	FB, 1/4FL	31.70		
	DISPOSAL FACILITY, DISPOSAL FEES AND TAXES (WBS 4.13)											Subtotal =	$ 1,980
Unit	Disposal Fees & Taxes	cf	150.00	13.20	$ 1,980								
				Subtotal Unit Costs	23,397								
				SAMPLES	19								
				UNIT COST PER SAMPLE	**1,231**								

Labor and Equipment Rates used to Compute Unit Cost											
Crew Item	**Rate $/hr**	**Abbre-viation**	**Crew Item**	**Rate $/hr**	**Abbrev-iation**	**Equipment Item**	**Rate $/hr**	**Abbrev-iation**	**Equipment Item**	**Rate $/hr**	**Abbrev-iation**
Field Team Lead	73.65	FTL	Project Manager	100.00	PM						
Industrial Hygienist	66.48	IH	Sample Technician	55.00	ST	Pickup	9.02	P			
Radiation Ctrl Technician	52.12	RCT				Flatbed Truck	25.48	FB			
Test Engineer	52.12	TE	Equipment Operator	44.66	EO	Small Tools	1.57	ST			
Radiological Engineer	86.48	RE	Truck Driver	46.79	TD	Fork Lift	6.62	FL			

Notes:

1. Unit cost = Total Cost / Qty
2. Abbreviations for units: ea = each, cf = cubic feet
3. Other abbreviations: PPE = personal protective equipment, Decon = Decontaminate, Loc = Location, Equip = equipment, Tech = Technician, Prod = Production.

Table C-3. Innovative Technology Cost Summary

Fixed/ Unit Costs	Work Breakdown Structure	Unit	Unit Cost $/Unit	Quantity	Total Cost	Computation of Unit Cost							Comments
						Prod Rate	Duration (hr)	Labor Item	$/hr	Equipment Items	$/hr	Other $	
	Facility Deactivation, Decommissioning, & Dismantlement												**TOTAL = $ 22,073**
	INVESTIGATIONS AND MONITORING/SAMPLE COLLECTION, CONTAMINATED BUILDING/STRUCTURES SAMPLES (WBS 4.07.14)												Subtotal = **$ 20,619**
Fixed	ALARA Review	Hr	86.48	4	$ 346								
Fixed	Init. Pickup/Check Equip.	Hr	183.31	1	$ 183		1	RCT,2ST	162.12	GLD,ROB,PU	21.19		
Fixed	Project Manager	Hr	100.00	8	$ 800								
Unit	Scanning Activity											Scanning Activity	
						73.65	21	TL	1546	PPE	13.60	286	
						66.48	21	1/4IH	349	GLD	23.09	485	
						52.12	21	2RCT	2189	RP	10.62	223	
						52.12	21	2TE	2189	2-PU	2.93	61	This equip. on Standby
						84.09	21	ROE	1766	ST	1.57	33	
						55.00	21	RT	1155				
		Hr	489.65	21	**$ 10,283**				**9,195**			**1,088**	
Unit	Other Activities											Other Activities	
						73.65	18	TL	1326				
						66.48	18	1/4IH	299	GLD	6.18	111	This equip. on Standby
						52.12	18	2RCT	1876	RP	2.47	44	This equip. on Standby
						52.12	18	2TE	1876	2-PU	18.05	325	
						84.09	18	RE	1514	ST	.47	8	This equip. on Standby
						55.00	18	RT	990				
		Hr	465.01	18	**$ 8,370**				**7,881**			**489**	
Fixed	Return Equip. to Storage	Hr	183.31	1	$ 183		½	RCT,2ST	162.12	GLD,ROB,PU	21.19		
Fixed	Final Post Job Briefing	Hr	453.68	1	$ 454		1	IH,2RCT,2RE,2ST	453.68				
	MATERIALS HANDLING/TRANSPORTATION (WBS 4.32)											Subtotal =	**$ 269**
Unit	Solid Waste Transport	Hr	89.65	3	$ 269		3	TD, 1/4 EO	57.96	FB, 1/4FL	31.70		
	DISPOSAL FACILITY, DISPOSAL FEES AND TAXES (WBS 4.13)											Subtotal =	**$ 1,185**
Unit	Disposal Fees & Taxes	cf	150.00	7.9	$ 1,185								

Subtotal Unit Costs	20,107
SAMPLES	20
UNIT COST PER SAMPLE	**$ 1005**

Labor and Equipment Rates used to Compute Unit Cost											
Crew Item	**Rate $/hr**	**Abbre-viation**	**Crew Item**	**Rate $/hr**	**Abbrev-iation**	**Equipment Item**	**Rate $/hr**	**Abbrev-iation**	**Equipment Item**	**Rate $/hr**	**Abbrev-iation**
Field Team Lead	73.65	FTL	Project Manager	100.00	PM	Gamma Loc Dev	23.09	GLD			
Industrial Hygienist	66.48	IH	Sample Technician	55.00	ST	Pickup	9.02	PU			
Radiation Ctrl Technician	52.12	RCT				Flatbed Truck	25.48	FB			
Test Engineer	52.12	TE	Equipment Operator	44.66	EO	Small Tools	1.57	ST			
Radiological Engineer	86.48	RE	Truck Driver	46.79	TD	Fork Lift	6.62	FL			
Robotic Engineer	84.09	ROE				Robotic Platform	10.62	ROB			

Notes:

4. Unit cost = Total Cost / Qty
5. Abbreviations for units: ea = each; cf = cubic feet;
6. Other abbreviations: PPE = personal protective equipment, Decon = decontaminate, Loc = Location
Equip = equipment, Prod = Production, Tech = Technician

APPENDIX D
ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
Am-241	americium 241
CFA	Central Facilities Area
Co-60	cobalt 60
Cs-137	cesium 137
CsI	cesium iodide
D&D	decontamination and decommissioning
DC	direct current
DOE	Department of Energy
FCC	Federal Communication Commission
GHz	giga hertz (frequency range)
GLD	Gamma Locator Device
IH	industrial hygiene
IID	Isotopic Identification Device
INEEL	Idaho National Engineering and Environmental Laboratory
KeV	kilo electron volts
LSDDP	Large Scale Demonstration and Deployment Project
MeV	mega electron volts
MHz	million hertz (frequency range)
mR/hr	milli rem per hour
NBA	North Boulevard Annex
NETL	National Energy Technology Laboratory
NIKIMT	The Research and Development Institute of Construction Technology
OST	Office of Science and Technology
PBF	Power Burst Facility
pCi	pico curie
PPE	personal protective equipment
RCT	radiological control technician
TAN	Test Area North
TMS	Technology Management System
TSDS	Technology Safety Data Sheet